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# **1 INTRODUCTION**

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# CHAPTER ONE:

## INTRODUCTION

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Quality Control/Quality Assurance (QC/QA) is often used synonymously with the term Quality Assurance (QA). AASHTO defines Quality Assurance as "All those planned and systematic actions necessary to provide confidence that a product will perform satisfactorily in service." This definition considers QA to be an all encompassing concept which includes quality control (QC), acceptance, and independent assurance (IA). The Indiana Department of Transportation (INDOT) further defines the QC/QA Program by differentiating the duties of the Contractor and INDOT; the Contractor is responsible for all QC (process control) activities and INDOT is responsible for acceptance of the material (QA).

A better understanding of the QC/QA concept can be made if the characteristics of the specifications are considered. These include:

1. QC/QA recognizes the variation in materials and test methods.
2. QC/QA uses a statistical basis that is applied and modified with experience and sound engineering judgement.
3. QC/QA places the primary responsibility on the Contractor for production control.
4. QC/QA makes a clear delineation between process control and acceptance testing.

The advantages of this type of specification include the proper allocation of responsibility for quality between the Contractor and INDOT, more complete records, and statistically based acceptance decisions. The Contractor has a greater choice of materials, and can design the most economical mixtures to meet specifications. Finally, there is a lot-by-lot acceptance so that the Contractor knows if his operations are producing an acceptable product.

The Quality Assurance Training Program is designed for both INDOT and Contractor's personnel. Although the responsibilities of the certified technician may or may not apply to both, the information presented in this training course is valuable in understanding the production of quality Superstructure Concrete.

## **CERTIFIED TECHNICIAN PROGRAM**

The certified technician is the cornerstone of the Quality Assurance Program. Without the certified technician determining the quality and consistency of the concrete being produced, bridge deck performance problems are certain. This fundamental shift of quality control from INDOT to the Contractor is important because it places control of the material in the hands of the Contractor.

It is the responsibility of the certified technician to test the quality and consistency of the concrete being produced. This job however does not stop at this point. The certified technician must also ensure that the concrete maintains this consistency by monitoring the materials at the plant. Finally, and most important, the certified technician must know what action to take when the materials deviate from specifications.

## **SYMBOLS**

For the purposes of QC/QA Superstructure Concrete we are specifically interested in the following units:

Slump -- in. (inches)

Unit Weight --  $\text{lb/ft}^3$  (pounds per cubic feet)

Compressive Strength --  $\text{lb/in.}^2$  (pounds per square inch)

Flexural Strength --  $\text{lb/in}^2$  (pounds per square inch)

Portland Cement Content --  $\text{lb/yd}^3$  (pounds per cubic yard of concrete)

Temperature -- °F (degrees Fahrenheit)

Lot/Sublot Size --  $\text{yd}^3$  (cubic yards)

Lot/Sublot Length -- ft (feet)

Evaporation Rate --  $\text{lb/ft}^2/\text{h}$  (pounds per square feet per hour)

Wind Velocity -- mph (miles per hour)

## ROUNDING

When calculations for quantities of material or test values are required, rounding in accordance with the standard "5" up procedure is used as follows:

1. When the first digit discarded is less than 5, the 1st digit retained should not be changed.

Examples:                    2.4 becomes 2  
                                      2.43 becomes 2.4  
                                      2.434 becomes 2.43  
                                      2.4341 becomes 2.434

2. When the first digit discarded is 5 or greater, the last digit retained should be increased by one unit.

Examples:                    2.6 becomes 3  
                                      2.56 becomes 2.6  
                                      2.416 becomes 2.42  
                                      2.4157 becomes 2.416

QC/QA Superstructure concrete specifications and procedures require test values to be calculated to the nearest figure as indicated in Figure 1.1

| Property                       | Nearest<br>10<br>Units<br>(00) | Nearest<br>Whole<br>Unit<br>(0) | First<br>Decimal<br>Place<br>(0.0) | Second<br>Decimal<br>Place<br>(0.00) | Third<br>Decimal<br>Place<br>(0.000) |
|--------------------------------|--------------------------------|---------------------------------|------------------------------------|--------------------------------------|--------------------------------------|
| <b>Concrete</b>                |                                |                                 |                                    |                                      |                                      |
| Rapid CI<br>Permeability       | X                              |                                 |                                    |                                      |                                      |
| Slump                          |                                |                                 |                                    | X                                    |                                      |
| Unit Weight                    |                                |                                 | X                                  |                                      |                                      |
| Air Content                    |                                |                                 | X                                  |                                      |                                      |
| Compressive<br>Strength        | X                              |                                 |                                    |                                      |                                      |
| Evaporation<br>Rate            |                                |                                 |                                    | X                                    |                                      |
| W/(C+P+SF)                     |                                |                                 |                                    |                                      | X                                    |
| <b>Aggregate</b>               |                                |                                 |                                    |                                      |                                      |
| Gradation                      |                                |                                 | X                                  |                                      |                                      |
| Moisture                       |                                |                                 | X                                  |                                      |                                      |
| Absorption                     |                                |                                 |                                    | X                                    |                                      |
| Bulk Specific<br>Gravity (SSD) |                                |                                 |                                    |                                      | X                                    |

FIGURE 1.1

## VOLUMETRICS

Proportioning concrete by the absolute volume method requires calculating the volume of each component necessary to make a single unit (ft<sup>3</sup>) of concrete. Volumes are subsequently converted to design weights, which then become the basis for actual production of concrete from the plant. Specific gravity is the means to convert from units of volume to weight. The definition of specific gravity and equations relating specific gravity to unit weight and volume are as follows:

Specific Gravity -- the ratio of the weight in air of a unit volume of a material to the weight of the same volume of water at stated temperatures.

### Weight to Volume

$$V = \frac{W}{G \times 62.27}$$

where:

V = Volume in ft<sup>3</sup>

W = Weight in lb

G = Specific Gravity

62.27 = Density of Water in lb/ft<sup>3</sup> at 73.4°F

Example:

Weight of Cement = 658 lb

Specific Gravity of Cement = 3.150

$$V = \frac{658}{3.150 \times 62.27}$$

$$= 3.35 \text{ ft}^3$$

### Volume to Weight

$$W = V \times G \times 62.27$$

Example:

Volume of Coarse Aggregate = 10.32 ft<sup>3</sup>

Bulk Specific Gravity (SSD) of Coarse Aggregate = 2.658

(Bulk Sp. Gr. (SSD) is used for Aggregates)

$$\begin{aligned} W &= 10.32 \times 2.658 \times 62.27 \\ &= 1708 \text{ lb} \end{aligned}$$

## RATE OF EVAPORATION

The rate of water evaporation determination is one procedure used to decide if protective measures are required to prevent the early loss of moisture from the concrete. The equation used for the evaporation rate contains several calculations that may be difficult. Included below is the equation and further mathematical explanation of some of the values.

$$E = [T_c^{2.5} - (r \times T_a^{2.5})] [1 + 0.4V] \times 10^{-6}$$

where:

E = evaporation rate, lb/ft<sup>2</sup>/h

T<sub>c</sub> = concrete temperature, °F

T<sub>a</sub> = air temperature, °F

r = (relative humidity %) / 100

V = wind velocity, mph

$$T^{2.5} = T \times T \times \sqrt{T}$$

$$10^{-6} = 0.000001$$